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MAXIMUM ATTAINABLE ACCURACY OF ULTRA-WIDEBAND ESTIMATION OF RANGE*

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The paper considers characteristics of the maximum likelihood estimate and the Bayes estimate in the case of a quadratic loss function and with abnormal errors taken into account. Application of the Bayes algorithm is shown to diminish the range measurement errors in the threshold domain. Optimal duration of the sounding pulse corresponding to a minimum error of range measurement is determined.

In the last few years, pulses of nano- and pico-second duration have often been used for sounding signals [1–4]. Since the potential accuracy of a target's range measurement is inversely proportional to the sounding signal duration [5], application of such signals makes it possible to assess the range with an accuracy of several centimeters. The short-pulse signals and their sequences represent a special case of ultra-wideband signals (UWBS). The UWBS spectrum is extremely wide, and the action of such signals causes excitation of nearly all possible oscillations of the target under investigation, which in turn makes the observed response highly informative. An important property of UWBS is the lack of carrier frequency in them and, as a consequence, impossibility of classical description of radio signals with the aid of a complex-valued envelope.

In [1–5] and other literature, two algorithms of range estimation were considered: the maximum likelihood estimate (MLE) and the Bayes estimate (BE) at a quadratic loss function. The accuracy of both estimates was in fact characterized with variance of the effective estimate. Then a natural question arises: how close can the estimate variance thus obtained approach its true value depending on the signal-to-noise ratio (SNR), pulse shape, and length of a priori interval of the possible range values?

The applicability of any algorithm of measurement deteriorates substantially at small SNR and large a priori intervals of possible range values — due to emergence of abnormal errors and of threshold effects [4, 5]. Moreover, the use of variance of the effective estimate for description of range measurement accuracy may even lead to qualitatively wrong conclusions. Indeed, the variance of effective estimate tends to zero as the sounding pulse duration decreases. Nevertheless, a prohibitive decrease in the pulse duration, in the case of its limited energy or power, may result in deterioration of accuracy of range measurement because of threshold effects [4, 5]. In this connection, consider the characteristics of MLE and BE of range with regard for abnormal errors, and investigate the dependence of range measurement accuracy on the sounding pulse parameters.

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